Roe Herring Impoundment Research-Report on the 1982/1983 Studies

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ABSTRACT

Kreiberg, H., J. R. Brett, and A. Solmie. 1984. Roe herring impoundment research -- report on the 1982/1983 studies. Can. Tech. Rep. Fish. Aquat. Sci. 1261: v + 31 p.

A third year of testing the impounding of maturing herring in floating netpens was carried out in a field location, northern Gulf Islands, British Columbia. The present commercial-scale impoundment operation served to confirm the findings of the previous 2 years' studies at the research fishfarm, Departure Bay, British Columbia. Herring caught in early February 1983 matured normally in the impoundment, and did not spawn upon reaching full maturity. Roe yield and quality assessments indicated a high quality for the impoundment roe.

Secondary studies on impoundment at the research fishfarm provided results on stocking density, time of capture, and spawning releaser effects. A comparison of herring transport methods evolving from the secondary studies indicated serious deficiencies in present towed-seine transport of live herring for impoundment where extensive towing time and distance are involved. Results over the duration of the study indicate that among the 4 steps of capture, transport, impounding, and harvesting, difficulties are more likely to arise in the transportation step. The smaller-capacity live-barges used in studies to date provide one solution; a fourth and supplementary year of study is planned to examine improved alternative transport methods for large quantities of herring.

Key words: herring, impounding, survival, maturation, roe quality, live-transport, time of capture, netpen

RÉSUMÉ

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Le présent rapport porte sur la troisième année d'étude de la mise en captivité de hareng en maturation, dans des cages flottantes ancrées dans les eaux des îles Gulf septentrionales (Colombie-Britannique). Cette opération de mise en captivité à l'échelle commerciale a confirmé les découvertes réalisées au cours des deux années précédentes à la ferme piscicole expérimentale de la baie Departure (Colombie-Britannique). Le hareng capturé au début de février 1983 a atteint une maturité normale en captivité et n'a pas frayé. Le rendement de la rogue et ses évaluations qualitatives dénotent une qualité élevée du produit obtenu en captivité.

Des études secondaires de la mise en captivité menées à la ferme piscicole expérimentale ont généré des résultats sur la densité du stockage, le moment de la capture et les effets des déclencheurs de la fraie. Une comparaison des méthodes de transport du hareng, produite à partir des résultats des études secondaires, a révélé des insuffisances importantes dans le transport du hareng vivant par seine remorquée, quand la distance et le temps de remorquage sont élevés. Les résultats de l'étude montrent que sur les quatre étapes (capture, transport, mise en captivité et exploitation), il est plus probable que des problèmes surviennent au moment du transport. Les barges de moindre capacité utilisées jusqu'à maintenant au cours d'études représentent une solution pour le transport du hareng vivant. On planifie une quatrième année d'étude afin d'évaluer d'autres méthodes améliorées de transport de grandes quantités de hareng.

Mots clés: hareng, mise en captivité, survie, maturation, qualité de la rogue, transport à l'état vivant, temps de capture, cage en filet

I. INTRODUCTION

The focus of the 1982-1983 research effort was to round out the planned 3-year study with an impoundment duplicating a commercial operation, using seine-towed herring and a sheltered field site near an area of known herring abundance. Successful 6.5-ton[1] and 40-ton impoundments were made in spring 1981 and spring 19 2 respectively, at the research fishfarm at Nanaimo, B.C. In each year, additional experimental studies in netpens and laboratory tanks were undertaken. These are described respectively in Brett and Solmie (1982) and Kreiberg et al. (1982).

A suitable field site for the present work was found at Whaleboat Passage, between Ruxton and Pylades Islands, northern Gulf Islands, B.C., lat. 123° 41'30" W, long, 49° 04'25" N (Fig. 1). We used the large netpen design developed in the previous year's work, and described in Kreiberg et al. (1982) (dimensions 27.7 m x 9.2 m x 7.6 m deep) loaded to about 35 tons of herring. A single such netpen, or multiples, would likely approximate a commercial impoundment.

An important aspect of the field operation was to identify any outstanding biological and technological problems, especially in regard to seine-towing of herring, that would affect the commercial feasibility of sac-roe herring impoundments.

As in previous years, the scope of the study required the cooperative efforts of experts in assessing roe quality and analysing body composition. These related studies are referred to in the text, and are included as a separate section. Brief mention is made of separate research at the Departure Bay fishfarm as it bears on previously reported impoundment work. For continuity, the reporting follows the form established in the previous reports, to which frequent reference is made.

II. CATCHING AND TRANSPORTING HERRING

1. CHARTERS

Catching of herring was done by the seiner PROGRESSOR under Don McNeil, using a standard west coast seine measuring 366 m x 91 m. Terms of the charter required proven abilities in live transport of herring. Fishing activities secondary to the purpose of this report were also carried out by the seiner MARY ROBERTA under Marvin Warnock with live-barge LIVEWAY (described in Brett and Solmie 1982), operating in the same area and at the same time.

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[1]As in other reports on this work, ton is used instead of tonne, because of the long experience of estimating catches in this unit.

2. CATCHING AND TRANSPORTING OF STOCKS

Fishing operations were carried out from 31 January to 5 February 1983 in upper Stuart Channel, in the vicinity of De Courcy and Ruxton Islands (Fig. 1). A total of 3 productive sets was made. Set 1 on the evening of 1 February was released after 4 hours of towing in the seine when the towing skiff failed. Set 2 on the evening of 2 February was towed to the impoundment site in the seine; however due to unexpected adverse tidal currents, the tow extended over 17 hours. At the impoundment site the herring were judged to be too badly descaled, and were released. The third set, made on the night of 4 February, was successful in reaching the netpen in apparently adequate condition.

Local conditions necessitated some changes in operation with regard to the successful set. Experience showed that catchable concentrations of herring were not occurring within the specified 2 nautical mile radius of Whaleboat Passage, and that longer tows with the seine were not desirable. Consequently, the netpen was detached from its moorings and towed into a nearby area more favorable for fishing, and anchored there temporarily. The set, initially estimated at 40 to 50 tons, was made in the upper extremity of Stuart Channel, and was towed for 3 hours to reach and be transferred to the netpen anchored off De Courcy Island. Towing was by the traditional method, a seine power-skiff connected via a rope bridle to the seiner's bow and stern and towing her broadside. The seine was pursed, and the rings and gable onboard. Tow speed was estimated at 1/3 knot.

For transfer of the loaded netpen back to the sheltered site, a bridle with approximately 150 m of heavy line was attached to one end of the rectangular frame. The pen was readied for travel by hanging large rocks inside the leading edge of the pen, to minimize deformation under tow; this was in addition to the integral anchor weights normally used to square off the netpen when moored. The seiner towed the netpen at the lowest possible engine speed, resulting in a speed over the bottom of 3/4 knot, and a tow duration of 5 hours. Speed through the water varied, increasing due to wash effects from the seiner, and decreasing due to fair tides of 1/4 to 1/2 knot. Upon reaching the Whaleboat Passage site the netpen was made fast once again to its moorings.

Fishing operations, as in previous years, were hampered by sea lion activity. Groups ranging up to several dozen attended on seining operations, attempting to feed on the herring and becoming trapped in the seine in numbers as high as 6. In addition to those trapped, others would surface under the seine, deforming it and frightening the herring. It was feasible to clear the seine through a combination of splashing with poles and plungers and releasing of extra corkline, over which the sea lions would eventually escape. However, in the case of the 17-hour tow, one sea lion remained in the net for over 12 hours before leaving. 'Seal-bombs' and overhead rifle shots were tried as in previous years, but proved ineffectual as before.

Other than sea lions, by-catch consisted almost entirely of anchovies (Engraulis mordax mordax); they comprised an estimated 10% of the catch in the successful set. Most became gilled in the mesh of the seine however, and the remainder were either released easily together with herring juveniles from the netpen, or died within a day or two from descaling and stress. Several unidentified rockfish and flatfish, a few squid (Loligo sp.) and midshipmen (Porichthys notatus) were also noted. Five herring tags were recovered, 4 having been placed in the preceding November, 2 at Chemainus and 2 at Boulder Point, and 1 in December at De Courcy Island.

III. SITE AND HOLDING FACILITY

1. SITE CRITERIA

Whaleboat Passage was selected over other possible sites in the area for reasons of proximity to herring stocks, good water depth (14-22 m), and the shelter provided by Ruxton, Pylades, and Whaleboat Islands (Fig. 1). Clearances were obtained from the Provincial Parks Branch regarding foreshore lease, and from the Federal Department of Transport regarding Canada Shipping Act requirements for a floating moored construction.

2. FLOAT

The actual netpen was suspended inside a rectangular float topped with a 1-m wide decked walkway around the netpen perimeter. A 30.8 m x 12 m impoundment float with a 27.7 m x 9.2 m pond opening was constructed by Topper Industries of Vancouver, to the design described in Kreiberg et al. (1982), using the T-23-F construction strength specification. Lengths of the float were partially assembled at Nanaimo after delivery in sections by truck. The research vessel CALIGUS towed the float sections and related gear, such as netpens and anchors, to Whaleboat Passage. There, the vessel and crew acted as a support unit during final assembly and mooring of the float.

3. INSTALLATION

The impoundment float was moored in an east-west direction, presenting a minimum profile to the easterly exposure to Pylades Channel. Average water depth at the site was 16 m. Eight 363-kg anchors on 13 mm mooring chain were used to secure the float. Length of chain used was 1.5 times the depth at individual anchor locations. The following procedure was used in setting the anchors (Fig. 8 refers):

1) A 50-kg weight was dropped on 13 mm rope from each corner of the float, as a temporary anchor.

2) Temporary 20 mm ropes were run from each end of the float diagonally to the beach on Whaleboat Island. These 2 lines acted as spring lines to take the pull of the chain and anchor for the initial 2 anchor settings.

3) The 13 mm mooring chain was shackled to the shore-side mooring bracket at the east end of the float, then led across the deck of the float at a 45° angle, i.e. to the southeast. The support vessel carrying slack chain and anchor moved off until the chain was fully extended, after which the anchor was dropped.

4) The same procedure was carried out at the west end of the float on the shore side, the anchor being set in a southwesterly direction.

5) The next anchors set were one from the west end, in a northerly direction, and one from the east end, to the northeast.

The float was now stabilized in position, and the remaining 4 anchors were placed from the outside edge. Each corner now had 2 anchors, with their chains crossing one another on the flat deck. Chafing planks were set under the chain at points where the chain bore heavily on the float. The angles of the anchor chains were kept as much alike as possible, in order that no corner of the float carried an excessive portion of the strain. An outer predator net, followed by the inner knotless pond net, was installed by the support vessel, which carried both nets on its seine drum (nets as described in Kreiberg et al. (1982)). A 3-log breakwater was moored 15 m up-weather of the east end of the float to give protection from southeasterly storms. A light was fixed to the float, and day beacons installed, to conform to the Collision Regulations of the Canada Shipping Act.

4) PERFORMANCE

No problems were experienced either with the float and pen construction or with the mooring system. The combination of natural shelter and the breakwater kept the impoundment secure. Gale force winds were experienced, however, local sea conditions did not exceed moderate swell or chop. The stable deck of the float proved again to be a good working platform, drawing praise from commercial fishermen for its advantages over log floats. Removal of mortalities, taking of samples, and bulk-loading, whether from seine or from barge, were all carried out with ease and safety regardless of weather.

IV. HANDLING OF FISH

1. FISH TRANSFERS

Herring were transferred from towed seine to netpen by 'swimming' them across a temporary gate. At the netpen, the bow of the seiner was tied to the pen float, the stern swung out, and the seine brought into the vee between the seiner and the netpen. Lines on the netpen were slacked off allowing part of it to be pulled under the float and out, for lacing to the gable of the seine. A strip of large-mesh web had previously been attached to this section of the top edge of the netpen, allowing for a quick lacing together with the seine net. Cannonball weights were dropped onto the laced area, sinking it approximately 5 m, enough to form a fairly deep gateway for the herring to swim through as the seine was slowly drummed in. No fish escaped during transfer[2].

2. PROCEDURES FOR REMOVING SAMPLES OR MORTALITIES

Most handling details for the 27.7 m x 9.2 m netpen have been described already in Kreiberg et al. (1982). Additionally in 1982-83, two points are made. Firstly, the removal of approximately 10 tons of mortalities 2 days after capture was carried out by divers slitting a 1-m hole in the floor of the netpen and predator net and lacing it up again, as the deadweight was too much to haul to the surface (all subsequent mortalities were removed by the lifting and rolling process). Secondly, unwanted live anchovies and juvenile herring were released by lowering a section of top edge of the netpen below the surface. Due to their size-segregated schooling, the small fish were easily induced to swim out without the loss of any of the deeper-schooling large herring.

V. ENVIRONMENTAL CONDITIONS AND MEASUREMENTS

1. TEMPERATURE (Table 1, Fig. 2)

Water temperature was recorded daily at noon, from a sample taken at about 2 m depth, for the duration of the impoundment. Weekly mean temperatures over the period 3 February to 23 March varied little, rising

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[2]More details and an illustration of this method of unloading a seine are found in Gillis et al. (1982).

steadily from an initial 7.7°C to a final 9.3°C. The degree-day total for the impoundment period was 410.8; the total for the equivalent period at the Departure Bay fishfarm was 406.6 degree days. In comparison to previous years at the fishfarm, these totals were not exceptional; in 1981 and 1982, totals for the same period were 423.2 and 392.6, respectively.

2. SALINITY (Table 1, Fig. 2)

Surface water salinity was stable at 26.9°/.. ± 0.3 SD for the impoundment period. In comparison, the Departure Bay fishfarm recorded a mean of 27.0°/.. ± 0.8 SD for the same period in 1983, and 26.9°/.. ± 0.8 SD in 1982.

3. OTHER VARIABLES

Oxygen and turbidity levels were not monitored at the field site. Fieldbook notes indicated that variation in water turbidity similar to previous years at Departure Bay was observed at Whaleboat Passage, often linked to rainfall.

4. SITE SUITABILITY

The Whaleboat Passage site proved to be a good location for an impoundment, sheltered, well-flushed by tidal currents, and with moderate depth over a large area affording space for considerably more impoundments. Ready access from Vancouver Island was had via cruiser from Boat Harbor.

Predators caused no problems, despite a known sea-lion rock several miles away (Miami Islet, in mid-Stuart Channel). With careful maintenance of the cover-net laced over the netpen's surface, otters and seabirds were excluded. No predators penetrated the heavy predator net surrounding the netpen. We feel however that the security of the impoundment was largely a result of having a full-time caretaker at the site.

Although isolated compared to Departure Bay (site of previous impoundments), Whaleboat Passage received a steady flow of vessel traffic in most weeks. In the days immediately following the stocking of the impoundment, heavy concentrations of large herring were noticed around the netpen on several occasions, and later on, a small group of killer whales entered the passage; none of these remained in the area. No major herring spawnings had occurred nearby at time of conclusion.

VI. STOCK CHARACTERISTICS

A summary of the vital statistics of the stock is contained in Table 2. Close to 900 fish were sampled at catching time giving a sex ratio of 36% females. Final results from all sampling improved this percentage to 46, a more acceptable ratio for roe herring. Onboard sampling at the time of the set also indicated the presence of 6% immatures, and 6% anchovies. Subsequent sampling from the impoundment indicated 2% immature and no anchovies, reflecting the combined effect of gilling in the seine and successful release of live small fish from the impoundment.

From scale readings of samples taken from the netpen, the age class breakdown was[3]

Year	2	3	4	5	6	7	8	9
%	0.6	12.6	24.9	18.3	10.6	4.4	1.5	0.2

VII. FIELD SITE RESULTS AND DISCUSSION

1. PLAN

As already partly described (Section II (2)), some aspects of the research plan were modified in light of field conditions at the time. Herring were transferred to the field site by a combination of towed seine and towed netpen, and it was decided not to put the fish up for tender for commercial processing, but to rely on expert assessment of the roe yield and quality by the Technology Services Branch of the Department of Fisheries and Oceans. Reflecting successful experience with the 27.7 m x 9.2 m netpens in 1981-82, the loading density was to be increased from 8 kg/m^3 (0.5 lbs/ft^3, or 20 tons) to 13.6 kg/m^3 (0.86 lbs/ft^3, or 35 tons). With other herring impoundments active at the Departure Bay fishfarm to monitor spawning delay, there was no intent to hold the field site herring longer than one week post maturity.

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[3]A fish of age 2 would be in the second year of its life, i.e., 1+. Scale samples were taken in February and March, 4-10 weeks before the herring entered a new year of growth.

2. SURVIVAL

During the first 10 days of impoundment, a large number of herring died, clearly as a result of damage and stress sustained in the transport operation. Of the final mortality figure of 52.2%, close to 9/10 occurred in the first 10 days. Opportunistic infection with Sporocytophaga sp., a saltwater myxobacterium similar to the columnaris disease agent, was frequently noted in the dying fish, but was likely secondary to the main cause of mortality. The rapid decline in mortalities over the first 2 weeks ruled out any major complicating disease influence.

In line with our experience in holding herring, the remainder of the impoundment duration was accompanied by low mortality, approximately 8% over a period of 38 days. While it is impossible to separate the causes of the losses in the first 10 days, we ascribe roughly equal weighting to the seine-towing and netpen-towing operations; it is unlikely that the brief capture operation itself had any harmful effect. Figure 3 compares the survival of the Whaleboat Passage impounded herring (graph 2) to another impoundment using barge-transported herring (graph 1). Although there are differences in tonnage, site, and density, the advantage of barge transport is clear.

Behavior of the herring in the Whaleboat Passage netpen was no different from observations in similar netpens at Departure Bay. They were able to school and sound naturally, and a range of day and night observations merely confirmed the suitability of the netpen for holding herring.

3. MATURATION AND ROE YIELD

Progress of maturation

The gonosomatic index (GSI = gonad weight as percent of total body weight) was tracked by weekly sampling of at least 50 fish. Initial GSI was 15% for both sexes at capture. The GSI then rose steadily for the next 40 days. Levelling off, i.e. maturation, occurred for both males and females at the same time, at 25% (♀) and 22% (♂). Figures 4 and 5 show the form of development for GSI. In the case of the females, the Whaleboat Passage results can be compared to earlier results in Figure 6, which principally shows the effect on maturation of time of capture.

By the time the field operation was concluded, one week after maturation, there had been no spawning in the netpen, and no spent fish were found in samples. The netpen was fouled to some extent, but not as much as was generally the case in our previous longer-term impoundments.

Prediction of GSI development

Our experience in 1981-82 had shown that the maturation process could be characterized by linear regression for the 3-month period leading up to final maturation (Kreiberg et al. 1982). Using an initial sample and the 1981-82 regression $y = 7.842 + 0.233x$, we predicted maturity ($GSI^{♀} = 25$) on 15 March 1983. As can be seen in Fig. 6, the prediction was quite accurate; a

subsequent regression based on the Whaleboat Passage results pinpoints the occurrence of GSI ♀= 25 as 17 March ($y = 3.225 + 0.287\ x$).

A number of regressions have been developed for the various impoundments we have operated over the past 3 years, all characterized by slopes ('rate constants') ranging between 0.23 and 0.29, and compatible with a maturation date on, or very close to, 15 March. Correlation coefficients for all the regressions are well in excess of 0.9. The biological and management implications of such apparent consistency are of significance, and may provide additional insights into herring maturation.

Roe yield

The quality of roe was checked weekly by processing with brine, using a I to V rating scale, category I being the highest (see Section VIII, Co-operative Studies, Roe Yield). Since this expert grading was providing continuity with results in previous years, and since the stock initially was both low in percent females and composed of somewhat lower-grade fish than desired, we chose not to send the herring for auction and commercial processing as previously done. Accordingly, when a full week of holding at GSI ♀= 25 had passed, demonstrating initial delay of spawning, the balance of the herring were released.

Biomass estimation

Once again, subjective visual estimates were relied upon to assess numbers of fish. Our charter agreement called for delivery of 35 tons. As initially estimated by the charter skipper, 47 tons were delivered; final records show the actual quantity to have been approximately 38 tons. The size of the error margin probably only reflects our unfamiliarity with the higher stocking density used, and would be expected to drop with increasing experience.

VIII. COOPERATIVE STUDIES

1. ROE QUALITY

Sampling of 10- to 30-kg lots of herring from the Whaleboat Passage pen was started on 1 March 1983, and continued every 3 to 4 days until the fish were released on 23 March. Roe was either frozen or processed in brine solutions, and subsequently graded. The proportion of unripe roe decreased from over 85% on 1 March to about 5% on 18 March. The highest level of good quality roe was reached around the third and fourth weeks of March. During this peak period, the sum of percentage Grade I and II roe ranged from 59 to 85. It was noted that percentage Grade III roe was relatively high, indicating an abundance of smaller herring.

Upon conclusion of the Whaleboat Passage impoundment trial, the sampling program carried on using herring held at the Departure Bay fishfarm. The quality of most processed roe remained good until 2 May, by which time about 17% of the herring were completely spawned out.

Freeze-processing of roe yielded a higher percentage of finished product than did brine-processing (30.5% vs 25.7%). The proximate composition of the roe was in the normal range for commercial samples from wild stocks. Moisture ranged from 68.3% to 78.8%, protein from 16.4% to 25.1%, lipid from 1.9% to 4.6%, and total ash from 0.9% to 1.3%.

IX. TRANSPORT METHODS FOR LIVE HERRING

The methods of fish transport described in this report can be compared to the barging of herring, since fishing and barging activities incidental to the purpose of the present work took place at the same time in the same area. Briefly, another seiner (Section II, 1. refers) was catching herring for use in impoundment-related studies at the Departure Bay fishfarm, and transporting fish thereto by barge.

Observations from the seiner fishing for the Whaleboat Passage site made it clear that both a seine and a netpen deform under tow, the latter less so but still significantly. 'Boil-ups' of herring occurred in the towed seine, some apparently spontaneous, others caused by sea lions outside the seine. They occurred also in the towed netpen, when no sea lions were present, beginning at the mid to forward area of the pen and remaining stationary in the water as the towed netpen passed under them. Predictably, the 'boil-ups' then came in contact with the end wall of the netpen, resulting in descaling. The 'boil-ups' were not continuous, but alternated with periods of swimming with the netpen, 'following' the seiner.

In contrast, a live barge essentially moves herring in a static (but exchanging) body of water contained within its hull-space. The fish are not required to swim, and direct observations indicate that they distribute themselves throughout the load space, swimming only at low activity levels and in every direction (Kreiberg et al. 1982). Neither does the presence of sea lions outside appear to cause panic.

It is well-known among roe-on-kelp fishermen, who transport herring in towed seines, that a seine full of herring may either 'follow' the vessel when towing begins, or not; in the latter case, some or all of the set may have to be dumped as experience indicates, despite such innovations as two-boat tow configurations, or weights or frameworks suspended in the seine to prevent deformation. Under the best circumstances, tow durations are kept as short as possible, 3-4 hours or less. Even then, indications are that mortality approaching 30% may occur in a 2-3 week impoundment (Shields and Kingston 1982).

The experience in the 1982-83 season is summarized in Fig. 3, illustrating the disparity in survival between the two methods of live transport. Seasoned commercial fishermen were involved in both types of transport operations, and although there was no intended side by side comparison of transport methods, we feel that a comparison evolved, notwithstanding the inevitable differences in fishing locations, gear, and destinations. It is apparent that use of towed seine transport for impoundment stocking has important limitations; a major focus of the planned 4th year of impoundment research will be to improve towed netpen transport technology.

X. RELATED NETPEN-RESEARCH RESULTS

This section is included for continuity with previous reports on impoundment research. It covers, briefly, additional insights gained from work secondary to the main purpose of the 1982-83 research. Most of the following results were obtained at the Departure Bay fishfarm, in netpens described in Brett and Solmie (1982), or in Kreiberg et al. (1982).

1. DENSITY

Two sizes of netpen were stocked with herring from early February captures, transported to Departure Bay by barge. A 7.5 m x 7.5 m x 6 m netpen was loaded to 16 kg/m^3 (1.0 lb/ft^3) in a repeat of a density-stress trial in 1981-82; 3 smaller 4.5 m x 4.5 m x 6 m netpens were loaded to 5.4 kg/m^3 for use in spawning-releaser studies. Survival in all pens was good, and by conclusion, 113 days after impounding, no disease outbreak or major die-off had occurred. The current results are added to those from 1981-82 in Fig. 7.

2. TIME-OF-CAPTURE EFFECT

Of potential priority to operators of commercial impoundments is the question of how close to spawning time can herring be impounded and still yield the delay of spawning phenomenon. Variation in catching times of the stocks used in the present 3 years of research indicates that herring can be caught as late as 4 weeks prior to spawning and still mature normally and hold at maturity for a time. Progression of GSI over the maturation and normal spawning period is shown in Fig. 6 for 3 different times of capture for impoundment. Herring from the present season's catching displayed the expected 4-5 week holding period at full maturity in netpens at Departure Bay.

3. SPAWNING RELEASERS

The effect of milt and of substrate as spawning releasers was tested in netpens stocked with ripe fully mature herring, and hung with fresh Macrocystis kelp. The results were inconclusive. When a fouled netpen was exchanged for a clean netpen, and fresh kelp hung in, spawning did not occur within a short time. When milt was added, the behavioral stages identified by Stacey and Hourston (1982) as 'rising and milling', 'papilla extension', and 'substrate testing' were commonly observed; however, the fourth and final stage, 'substrate spawning', did not follow directly. Spawnings, sometimes substantial, occurred in a number of netpens hung with kelp, however the experience of 1981-82 was not repeated (at that time, herring were successfully induced to spawn by changing fouled netpens for clean). We regard our findings about spawning releasers as only preliminary.

XI. SUMMARY STATEMENT

The 1982-83 roe herring impoundment operations served principally to confirm, in a commercial-scale field situation, the results obtained in previous years at the Departure Bay fishfarm. Additionally, the transport phase of a commercial-size impoundment was seen to be a critical factor in success of the overall operation. With current transport methods other than live-barge, the potential for herring losses due to stress and physical damage remains high, where distances of more than 1/2 mile are involved.

As in the preceding 2 years, impounded herring matured normally and predictably; the date of final maturity could be closely predicted by linear regression from previous years' results. An extended holding period at full maturity without spawning was again confirmed. Field experience indicated that for the site chosen, in the northern Gulf Islands, the various natural factors, e.g., sea lions, predatory fish, environmental changes, and nearby stocks of wild herring, did not interfere with the impoundment's success. The large 27.7 m x 9.2 m netpen performed well in a field location.

We note that, as in the preceding 2 years of research, experience in fish culture and the handling of live fish undoubtedly contributed to the success of the operation. Skilled and experienced commercial fishermen carried out the charter work, and impounded herring were handled at all times so as to minimize stress and avoid damage.

In separate work at the Departure Bay fishfarm, milt was tried as a spawning releaser, with no marked success. A repetition of a high-density pen experiment (herring were stocked to 16 kg/m^3) did not result in serious mortality. A retrospective comparison of maturation trends from different times of capture revealed no difference for herring caught as late as 1 month prior to normal spawning time.

XII. ACKNOWLEDGMENTS

The measurements involved in the weekly sampling were mostly done by Elizabeth Mallett and Robert Kennedy. Their conscientious assistance in this regard, and in many other regular duties in maintaining two herring impoundments, is greatly appreciated.

We are grateful to charter boat skippers Don McNeil (PROGRESSOR) and Marvin Warnock (MARY ROBERTA) and their crews, as well as Pacific Biological Station staff members Bob McLaughlin, skipper of the CALIGUS, and crew Ed Wood, for their ready cooperation during the spring field operations. We thank Rick Hobbs, who kept watch over the impoundment for 2 months, and who provided welcome shelter for weekly sampling crews aboard the SAN PATRICIO.

Scientists J. Cheng and H. Tsuyuki submitted roe quality assessments essential to the evaluation of the current year's work, for which we are grateful. The continued joint study of commercial and research aspects of herring impoundments was made possible by co-funding from the Fisheries Development Program of the Department of Fisheries and Oceans.

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Table 1. Weekly records of average environmental conditions monitored in the impoundment areas (1983).

	Departure Bay fishfarm			Whaleboat Passage	
Week	t°C	Sal. °/..	Turb.(m)	t°C	Sal. °/..
Feb. 1-5	7.5	26.6	8.8	7.7	27.3
6-12	7.8	26.0	7.2	7.9	27.0
13-19	8.0	25.5	4.0	8.1	26.9
20-26	8.4	26.8	6.4	8.5	27.1
27-5	8.0	26.7	9.0	8.0	26.7
Mar. 6-12	8.6	27.2	6.0	8.7	26.6
13-19	9.5	27.1	7.0	9.0	27.4
20-26	9.5	27.9	3.1	9.3	26.5
27-2	8.4	28.9	5.9		
Apr. 3-9	9.7	26.9	8.1		
10-16	9.9	27.9	8.4		
17-23	11.5	27.9	7.1		
24-30	12.5	27.5	4.6		
$\bar{X}$	-	27.1	6.4	-	26.9
SD	-	0.8	1.6	-	0.3
SE	-	0.2	0.4	-	0.1

Table 2. Vital statistics of herring impounded at Whaleboat Passage site, 5 February to 23 March 1983, as determined by weekly sampling.

Mean length, mm	203.3
Mean weight, g	112.5
% ♀	~~45~~ 58
Density, kg/m^3 (lb/ft^3)	13.6 (0.85)
Survival to maturity, %	48.9
GSI (♀) at maturity, %	26.6*

*corresponds to 12.2 by standard DFO field test.

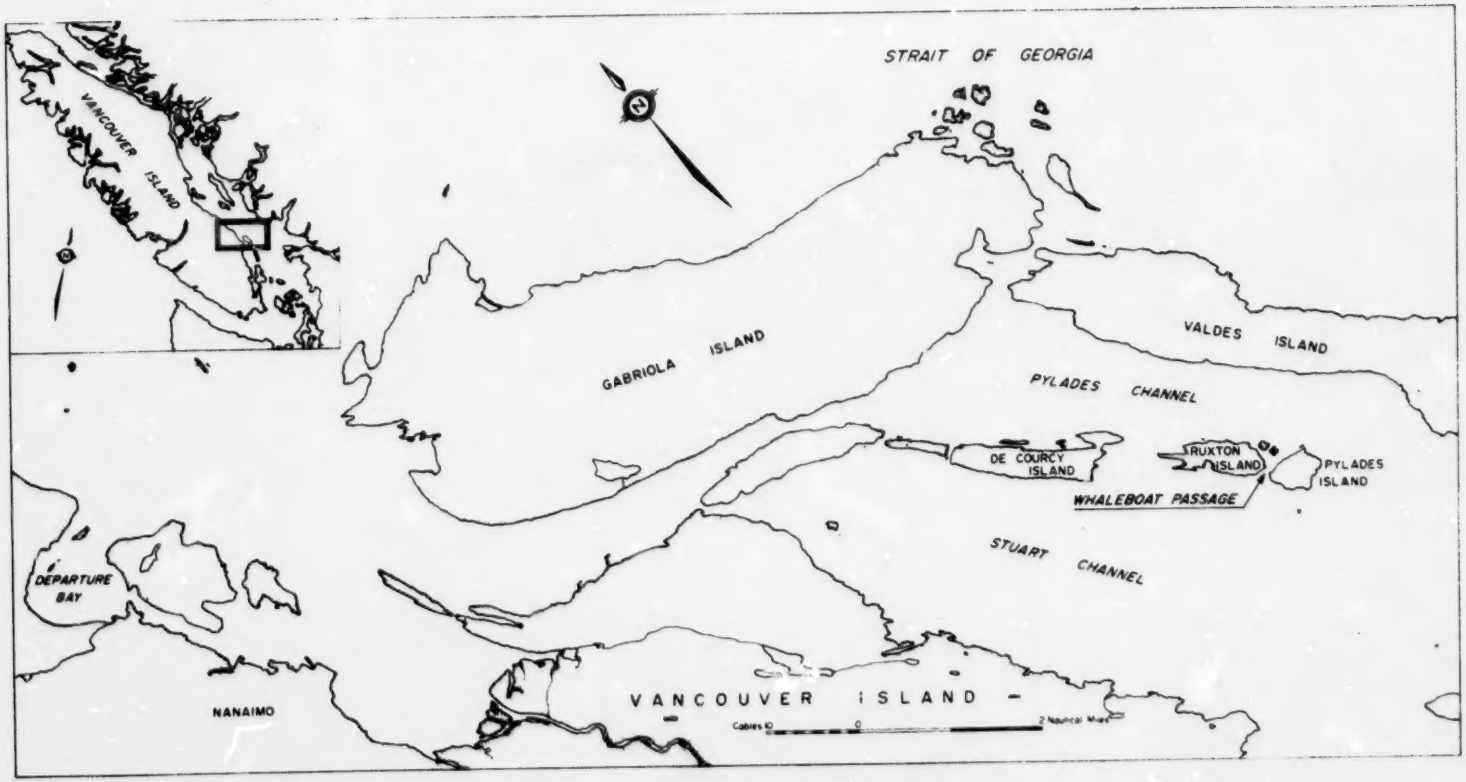

Fig. 1. Detail of east coast of Vancouver Island near Nanaimo, showing upper Gulf Islands area and experimental impoundment site at Whaleboat Passage.

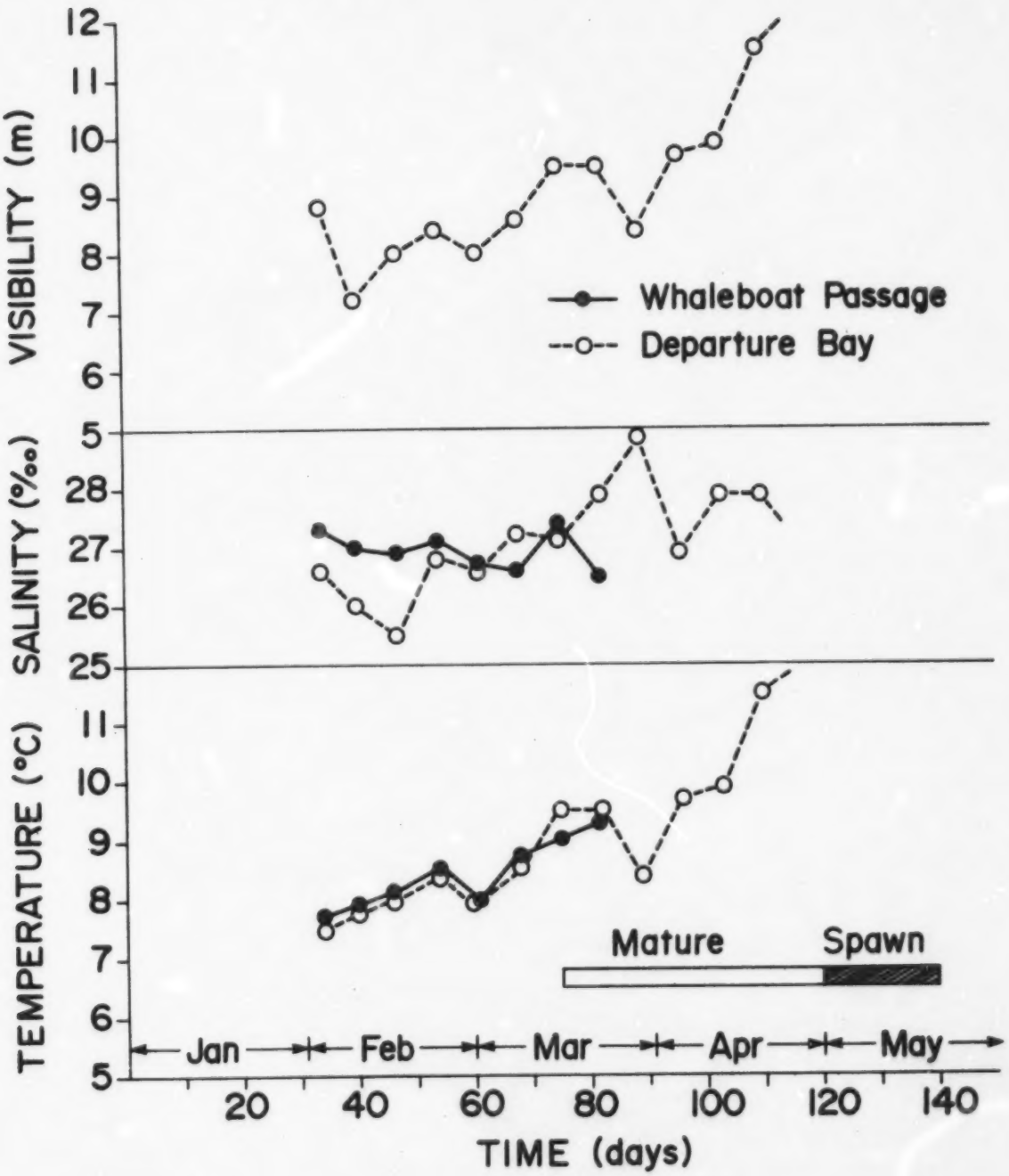

Fig. 2. Record of environmental conditions, February to April, 1983, at the impoundment site, Whaleboat Passage. Points are weekly means, and the bar at lower right indicates progress of maturation in held herring stocks. For comparative purposes, 1983 records for the Departure Bay fishfarm are shown in broken line.

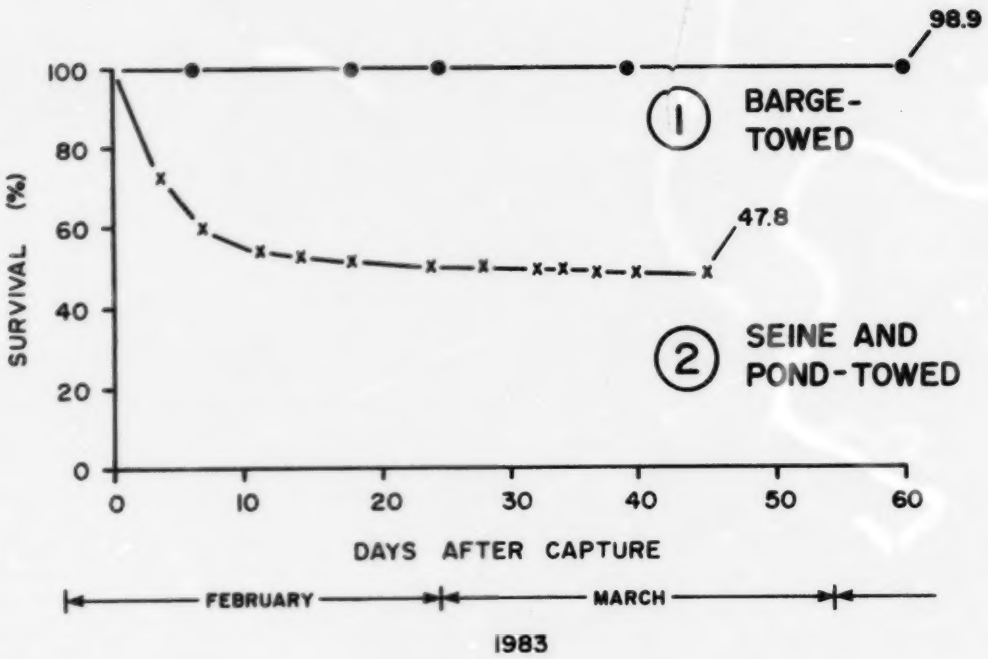

Fig. 3. Comparison of survival of herring held in 27.7 m x 9.2 m netpens following transport from capture site by barge (upper) and by combined seine and towed netpen (lower). Initial tonnage and density were: 16.5 tons, 8 kg/m^3 (0.50 lbs/ft^3) barged; 37.9 tons, 13.6 kg/m^3 (0.85 lbs/ft^3) seine and netpen-towed. Stocks were captured between 4 and 8 February 1983.

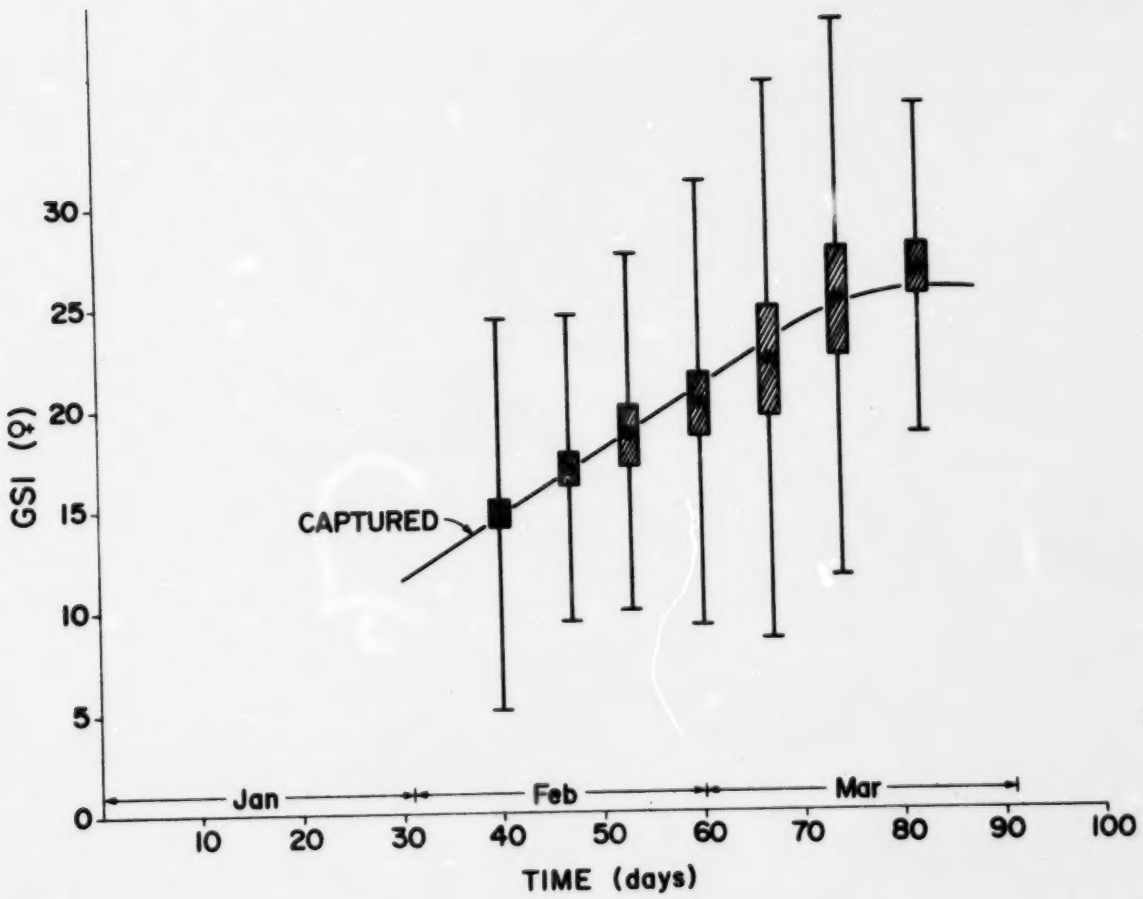

Fig. 4. Change in gonosomatic index of female herring held in a netpen at Whaleboat Passage, 5 February - 23 March 1983 (Mean ± 2 SE, ± 2 SD). GSI = 25 occurred on day 76 (17 March).

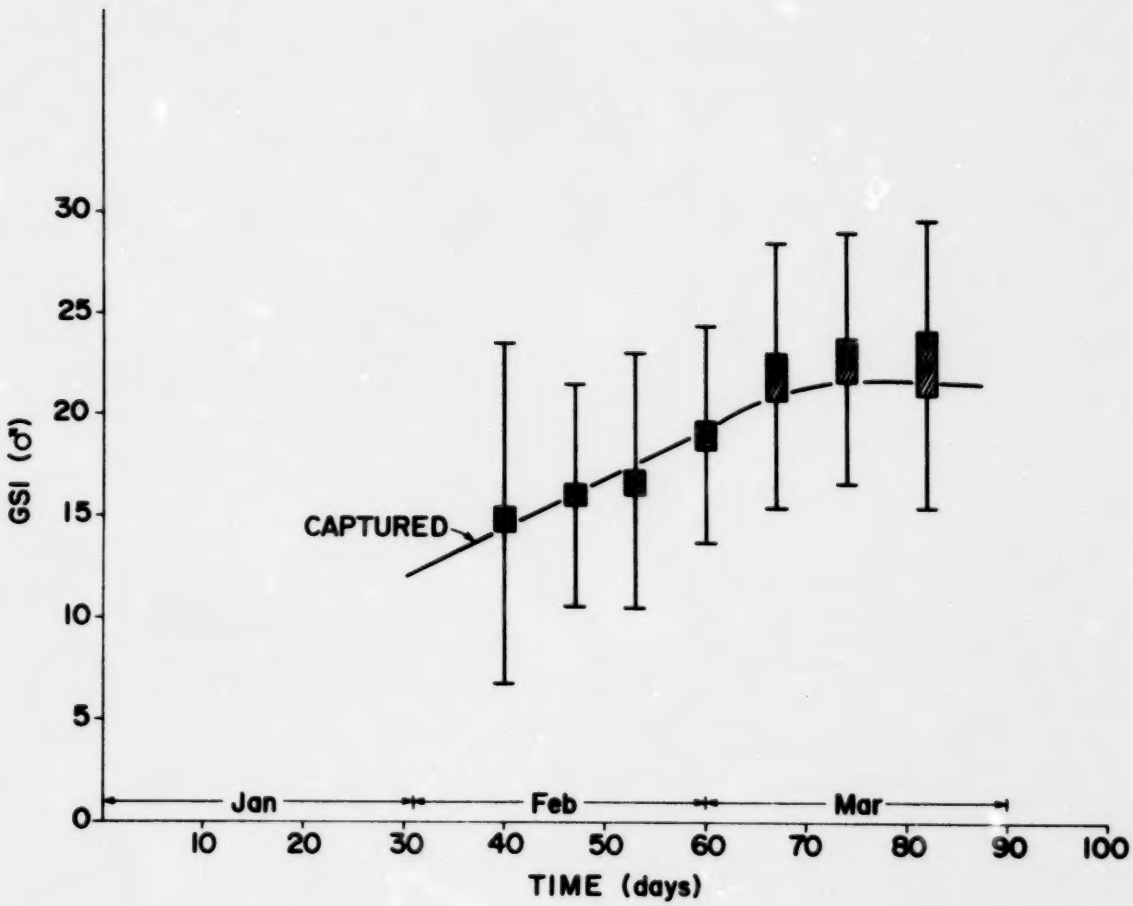

Fig. 5. Change in gonosomatic index of male herring held in a netpen at Whaleboat Passage, 5 February - 23 March 1983 (Mean ± 2 SE, ± 2 SD). GSI = 20 occurred on day 64 (5 March).

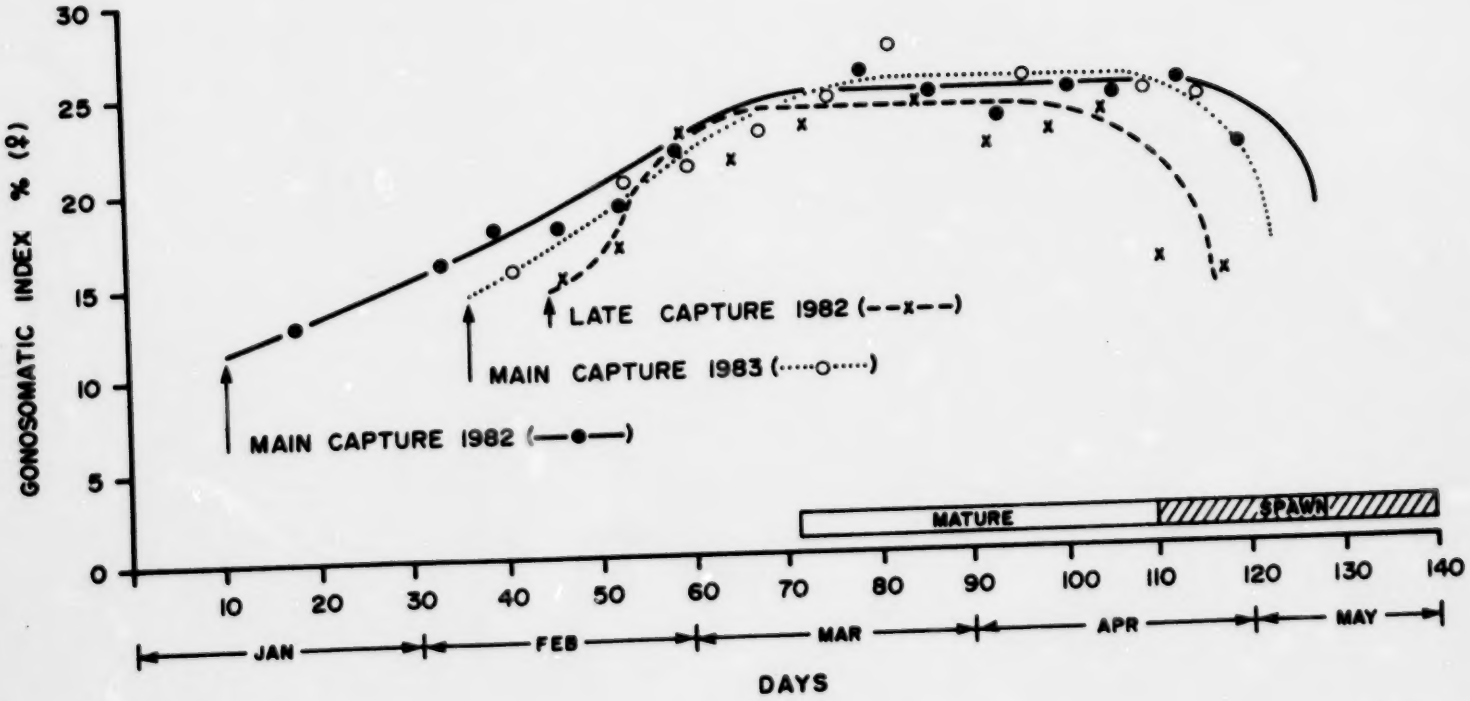

Fig. 6.
Comparison of development of GSI in female herring in relation to time of capture and impounding. Catches were made, in 1982 on 8 January (48 tons) and 15 February (7 tons), and in 1983 on 4 February (45 tons), ± 1 day. In each case, fish were judged mature (GSI (♀) = 25) within a day or two of 15 March (day 74).

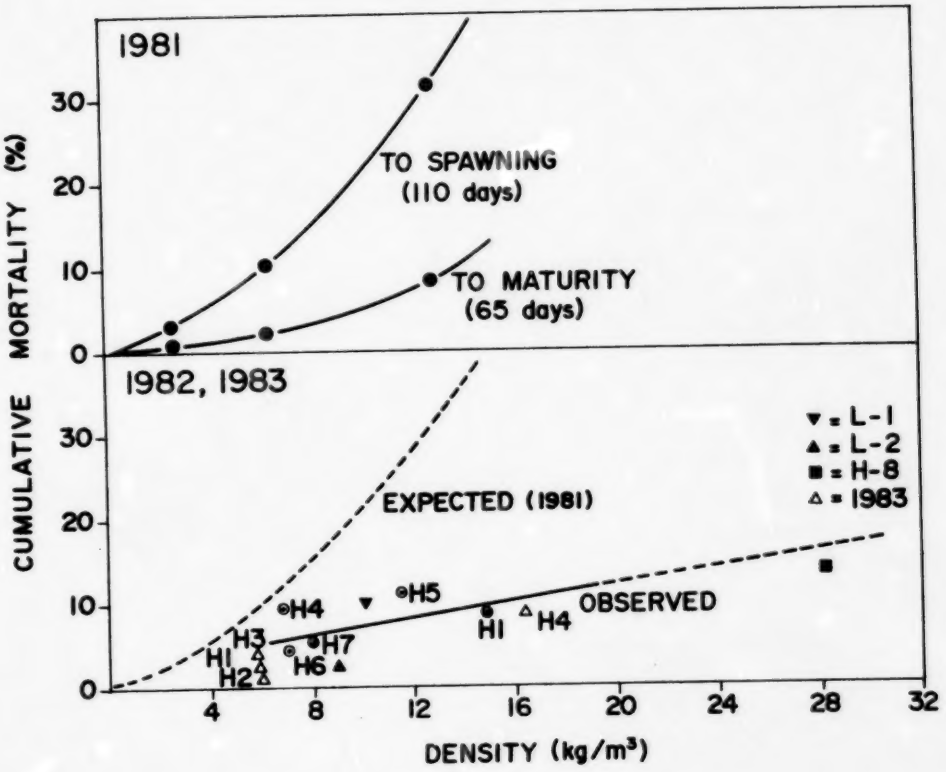

Fig. 7. Comparison of density-mortality curves for 3 seasons of impounding roe herring at the Departure Bay fish farm. Upper frame gives curves for mortality to maturity (65 days) and to spawning (110 days) for herring impounded in 1981. The lower frame shows the 110-day curve from 1981, to which netpens H1, H4, and H5 were intentionally stocked in 1982 in order to confirm initial results. The results observed are shown by the straight line, $y=2.667 + 7.409$, $r=0.44$. Additional points included are the commercial-test pens (L1 and L2) and their monitors (H6 and H7), and the late-capture group (H8); the latter was held only for 35 days from 15 February 1982. The 1983 results are added to the lower frame (H1-4).

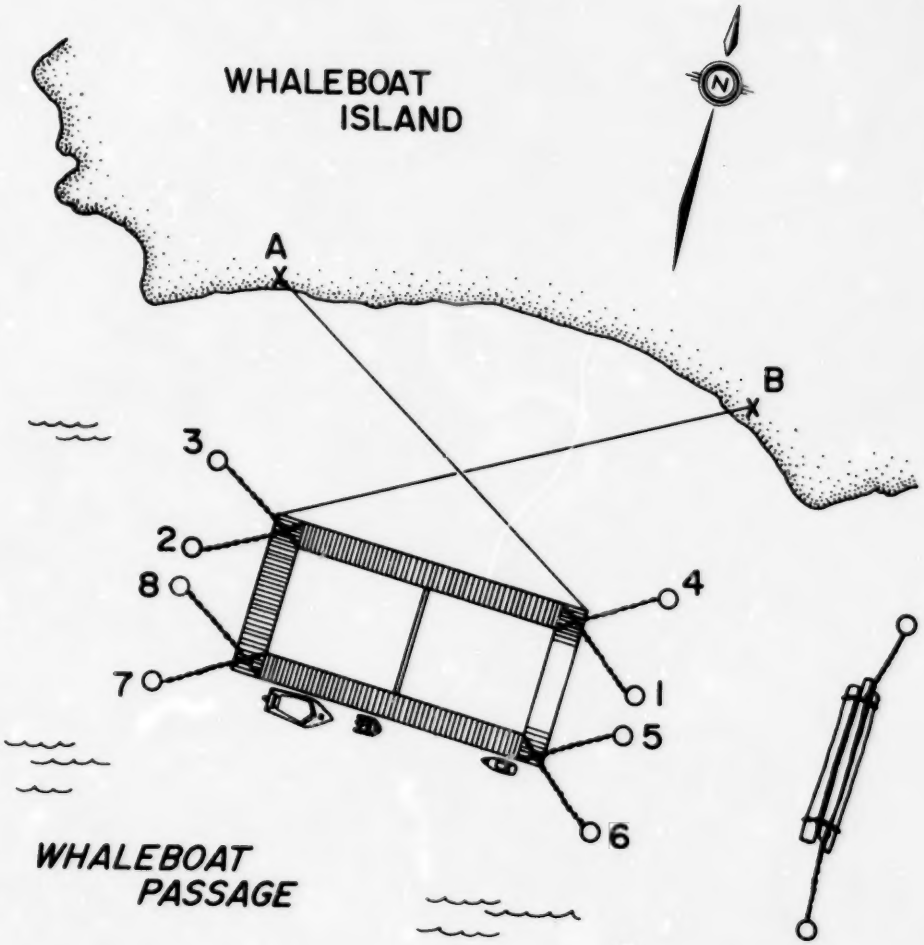

Fig. 8. The impoundment float in place showing the mooring system and breakwater. Temporary springlines A and B were removed once the anchors were set. The anchors are numbered in the order set [refer to text Section III (3)]. Not to scale.

POOR

QUALITY

ORIGINAL